Tools and Technology Note

Field Sedation of Coyotes, Red Foxes, and Raccoons With Medetomidine and Atipamezole

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ABSTRACT We chemically restrained free-ranging coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), and raccoons (*Procyon lotor*) using medetomidine antagonized by atipamezole. All coyotes and 80% of red foxes were sedated with mean ± standard deviation doses of 0.12 ± 0.02 mg/kg and 0.14 ± 0.02 mg/kg medetomidine, respectively. Seventy-seven percent of raccoons were sedated with 0.21 ± 0.05 mg/kg medetomidine. In all species we observed occasional movement, muscle rigidity, and partial-arousal during sedation. Animals were alert within 4.3–8.6 ± 3.5–8.4 min following atipamezole at 0.4 mg/kg. Medetomidine and atipamezole provided safe handling in most animals and rapid recovery without use of a controlled substance. At these doses, biologists in the field should be prepared to administer a supplementary dose of medetomidine to some animals depending on ambient conditions and the objectives of the restraint event. (JOURNAL OF WILDLIFE MANAGEMENT 72(5):1267–1271; 2008)

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Chemical restraint is a valuable tool in wildlife management and research. Many types of projects require safe handling of animals in field or clinical settings; for example, captive care of animals as part of reintroduction efforts and telemetry studies of free-ranging populations (Dzialak et al. 2001, Beasley et al. 2007). Effects of chemicals used to restrain animals can vary depending on attributes of the restraint event including drug type, species, dose, physical characteristics of the animal (e.g., body size), and ambient conditions (Kreeger and Arnemo 2007). Characterizing the efficacy of different drugs and dose regimes on various wildlife species is useful, particularly in field settings where conditions can vary.

Medetomidine is a potent α_2-adrenoreceptor agonist, classified as a sedative, which depresses the central nervous system by regulating the release of noradrenaline. Medetomidine is highly selective for both pre- and postsynaptic receptors so undesirable neurologic effects are infrequent (Jalanka and Roeken 1990). Atipamezole is a highly specific α_2-adrenergic antagonist that competitively reverses the effects of medetomidine (Jalanka and Roeken 1990). Medetomidine is often combined with an anesthetic such as ketamine to enhance analgesia and muscle relaxation (Haigh 1982, Clark and Jessup 1992). However, in field settings where brief or noninvasive procedures such as radiocollaring are common or where ambient conditions may be harsh, prolonged sedation or anesthesia often are undesirable. Use of medetomidine alone offers promise in such situations because medetomidine-induced sedation can be fully reversed with atipamezole. In contrast, common anesthetics such as ketamine and tiletamine (a component of Telazol®) have no known reversal agent so their use even in combination with medetomidine can produce residual dissociative effects (Kreeger and Seal 1986*b*). Use of medetomidine with and without atipamezole has been reported for many species (Jalanka 1989, Barnett and Lewis 1990, Jalanka and Roeken 1990), including canids and other carnivores (Arnemo et al. 1994; Spelman et al. 1994; Kreeger et al. 1996; Dzialak et al. 2001, 2002).

As part of a project in which we studied stream-crossing behavior of waterfowl predators in the Deer Flat National Wildlife Refuge, Idaho, USA, we evaluated the use of medetomidine and atipamezole for reversible field sedation of 3 carnivore species including raccoon (*Procyon lotor*), red fox (*Vulpes vulpes*), and coyote (*Canis latrans*). The capacity for brief, reversible sedation was important in this setting because capture and radiocollaring of animals occurred in riparian habitat where residual drug effects could result in drowning. Raccoons have been restrained with sodium pentobarbital, phencyclidine, ketamine and xylazine, and Telazol (Bigler and Hoff 1974; Greenwood 1982; Deresienski and Rupprecht 1989; Belant 1995, 2004). Red foxes have been restrained with combinations of ketamine, xylazine, tiletamine, midazolam, phencyclidine, and promazine (Seal et al. 1970, Jessup 1982, Kreeger et al. 1990*b*). Likewise, coyotes have been restrained with combinations of ketamine, xylazine, fentanyl, droperidol, phencyclidine, and promazine (Seal et al. 1970, Mulder 1978, Jessup 1982, Kreeger and Seal 1986*a*). Use of medetomidine and atipamezole combinations has not been reported in raccoons, red fox, or coyotes. Our objective was to evaluate medetomidine with atipamezole antagonism of raccoons, red foxes, and coyotes under field conditions by monitoring anesthesia intervals (induction and alert times), effects of

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ambient temperature, and physiologic responses (rectal temp, pulse rate, and ventilation rate).

STUDY AREA

The study occurred in the Snake River Islands Section of Deer Flat National Wildlife Refuge, Idaho, USA. The Refuge was 4,600 ha; the Snake River Islands Section includes about 350 ha distributed over 159 islands on the Snake River (58 of which are privately owned). Vegetation on the islands was dominated by riparian shrub and forest species, and grassland species further inland including willow (*Salix* spp.), tamarisk (*Tamarix* spp.), eastern cottonwood (*Populus deltoides*), Great Basin wild rye (*Leymus cinereus*), and saltgrass (*Distichlis spicata*). Some agriculture (row crops) occurred on larger islands. Temperature averaged −1° C in January and 28° C in July; average annual precipitation was 26.9 cm with the majority occurring during November through March.

METHODS

We captured coyotes ($n = 10$), red foxes ($n = 30$), and raccoons ($n = 31$) in November 1998–March 2000 using soft-catch leg-hold traps (No. 1.5, Victor®; Woodstream Corporation, Lititz, PA) and mesh-wire live-traps (92 × 31 × 36 cm; EZ Catch Live Traps, Dallas, SD). For drug administration we manually restrained animals with a capture pole and administered medetomidine (Domitor®, 1 mg/ml; Pfizer Animal Health, Extor, PA) in the quadriceps musculature using a handheld syringe. We aimed to administer 0.1–0.2 mg/kg medetomidine based on estimated body weight. We supplemented the initial dose of medetomidine with additional medetomidine or ketamine (also based on estimated body wt; Ketaset®, 100 mg/ml; Aveco Co, Inc., Fort Dodge, IA) if the initial dose was insufficient (see below). We based supplemental drug doses on standard recommendations (Kreeger and Arnemo 2007). Precautions taken to minimize stress to captured animals included using a small field crew (typically 2 members), approaching trapped animals quietly by boat, and minimizing handling time. Upon loss of responsiveness to stimuli each animal received a physical assessment that included weighing, administration of broad-spectrum antibiotic (Aquacillin; Vedco, Inc., St. Joseph, MO) and parasiticide (Ivomec®; Merck and Company, Inc., Rahway, NJ), treatment of minor trap-related injury with a topical antibiotic (Betadine®; The Purdue Fredrick Company, Norwalk, CT), and radiocollaring.

We monitored induction time (min), defined as the time from injection of the initial dose of medetomidine until the animal was sufficiently sedated for handling. During sedation we recorded heart rate by palpation (beats/min [bpm]), ventilation rate by visual examination of thoracic excursions (breaths/min), and rectal temperature using a digital thermometer (° C). We recorded ambient temperature during each restraint event. Upon completion of the procedures we administered atipamezole (Antisedan®; 5 mg/ml, Wildlife Pharmaceuticals, Fort Collins, CO) intramuscularly (IM) in the quadriceps musculature at 0.4 mg/kg based on actual body weight. We administered atipamezole IM as opposed to intravenously (IV) because recovery is smoother and more predictable and time to recovery is not much longer than IV administration (Kreeger and Arnemo 2007). We recorded alert time (min), defined as the time from injection of atipamezole until the animal regained awareness, coordination, and mobility (Dzialak et al. 2001). We summarized data including doses (initial and supplementary) and timing of all recorded measurements. We restricted statistical analyses (SAS®; SAS Institute, Cary, NC) to animals for which one initial dose of medetomidine was sufficient. We used general linear models (analysis of variance; PROC GLM) to evaluate sex, species, ambient temperature, and interaction term effects on induction and alert times. We used multivariate analysis of variance (PROC GLM) to assess sex, species, ambient temperature, and interaction term effects on heart rate, ventilation rate, and rectal temperature. For instances in which medetomidine sedation was supplemented with additional medetomidine (red foxes; see below) or ketamine (raccoons; see below), we report and discuss physiologic differences between groups (i.e., single-dose animals vs. supplemented animals) rather than analyzing differences statistically. In all analyses, results were significant if $P \leq 0.05$ and are presented as mean ± standard deviation.

RESULTS

All coyotes ($n = 10$) were sedated with medetomidine at 0.12 ± 0.02 mg/kg (Table 1). Twenty-four of 30 red foxes were sedated with medetomidine at 0.14 ± 0.04 mg/kg. Compared to coyotes and foxes, we administered a higher initial dose of medetomidine to raccoons. Increasing the medetomidine dose was not a concern because of the wide margin of safety documented for this drug (Jalanka and Roeken 1990). Twenty-three of 31 raccoons were immobilized with medetomidine at 0.21 ± 0.05 mg/kg (Table 1). We aimed to maintain consistency in the dose of medetomidine among species but early in the study it became apparent that raccoons required a higher dose for sedation than did foxes or coyotes. For practical and ethical purposes (i.e., human and animal safety, the larger objectives of this research), we maintained use of this higher dose throughout the study. Readers should consider this when interpreting results on mean induction time and physiologic response. We observed no mortality or other complication during the chemical restraint process. However, we occasionally observed movement and partial arousal in immobilized animals. Mean induction time among animals sedated with one dose of medetomidine did not differ among species (despite raccoons having received a higher mean dose of medetomidine) or between sexes; we detected no species × sex interaction ($P > 0.05$; Table 1). We detected an effect of ambient temperature on induction time ($F_{6,47} = 4.78$, $P = 0.03$). Ambient temperature during the study was 5.9 ± 4.6° C (range −3.9–18.3° C).

Rectal temperature and pulse rate differed among species

Table 1. Drug dose, anesthesia intervals,[a] and physiologic response of coyotes, red foxes, and raccoons immobilized with medetomidine[b] and atipamezole, November 1998–March 2000, Snake River Islands Section of Deer Flat National Wildlife Refuge, Idaho, USA.

	Coyote ($n = 10$)		Red fox ($n = 24$)		Raccoon ($n = 23$)	
Parameter	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Medetomidine dose (mg/kg)	0.12	0.02	0.14	0.04	0.21	0.05
Medetomidine vol (ml)	1.3	0.2	0.67	0.2	1.3	0.4
Induction (min)	13.0	3.1	18.1	8.0	17.5	6.8
Temp (° C)	40.4	0.8	40.9	1.1	39.6	1.0
Temp (time recorded in min)[c]	31.7	17.7	41.0	17.6	32.4	11.6
Ventilation (breaths/min)	22.7	5.3	40.9	1.1	28.4	19.7
Ventilation (time recorded in min)[c]	31.6	18.1	41.6	18.5	33.3	12.8
Pulse (beats/min)	49.2	11.8	58.8	22.6	68.6	25.4
Pulse (time recorded in min)[c]	32.1	19.2	41.5	18.9	33.2	12.7
Atipamezole dose (mg/kg)	0.4		0.4		0.4	
Atipamezole vol (ml)	0.87	0.1	0.38	0.1	0.51	0.1
Alert (min)	8.0	3.8	4.3	3.5	8.8	8.4

[a] Induction time was the time from injection of the initial dose of medetomidine until the animal was sufficiently sedated for handling; alert time was the time from injection of atipamezole until the animal regained awareness, coordination, and mobility.
[b] Reported here are animals that we immobilized with one initial dose of medetomidine.
[c] Time elapsed between injecting medetomidine and recording the measurement.

with raccoons generally having lower temperature ($F_{6,45} = 10.1$, $P < 0.01$) and higher pulse rate than did coyotes or foxes ($F_{6,45} = 4.98$, $P = 0.01$; Table 1). We detected no sex effect, no effect associated with the amount of time elapsed between injection of medetomidine and the time at which physiologic measurements were made, and no interaction term effect for any physiologic parameter ($P > 0.05$); however, ambient temperature was associated with higher ventilation rate ($F_{6,45} = 8.60$, $P < 0.005$). We administered atipamezole 45.2 ± 20.7 minutes, 43.9 ± 13.5 minutes, and 42.4 ± 12.6 minutes post–medetomidine injection in coyotes, foxes, and raccoons, respectively. We observed no sex, species, ambient temperature, or interaction term effect on mean alert time ($P > 0.05$; Table 1).

Of 30 red foxes, 6 required an additional dose of medetomidine at 0.12 ± 0.03 mg/kg; we administered the second dose at 36.8 ± 12.4 minutes after the first dose, resulting in these foxes receiving a total medetomidine dose of 0.24 ± 0.05 mg/kg. These 6 foxes were effectively immobilized after receiving the second dose of medetomidine. Of 31 raccoons, 8 were not sufficiently sedated with 0.22 ± 0.05 mg/kg medetomidine. These raccoons received a supplementary dose of ketamine at 10.0 mg/kg, 28.7 ± 13.9 minutes after having received the medetomidine. The supplementary dose of ketamine effectively immobilized these raccoons. We recorded rectal temperature, pulse rate, and ventilation rate in animals that received supplementary medetomidine (foxes) or ketamine (raccoons) at 58.3 ± 16.6 minutes, 61.5 ± 21.2 minutes, and 59.8 ± 20.4 minutes, respectively, following initial administration of medetomidine in foxes and 47.3 ± 13.1 minutes, 45.2 ± 14.4 minutes, and 46.8 ± 13.8 minutes, respectively, following initial (only) administration of medetomidine in raccoons. In foxes that received supplementary medetomidine, mean body temperature (41.2 ± 0.7° C) and pulse rate (74.3 ± 7.6 bpm) were higher, and ventilation rate (25.2 ± 5.2 breaths/min) was lower than in foxes that received one dose of medetomidine (Table 1). In raccoons that received supplementary ketamine, mean pulse rate was higher (99.4 ± 8.9) than in raccoons that received only medetomidine (Table 1).

DISCUSSION

Medetomidine at 0.12–0.14 mg/kg induced moderate sedation in coyotes and most red foxes that would enable brief, noninvasive field procedures such as radiocollar attachment, collection of morphological data, or ear-tagging. Procedures that require palpation to detect injury or pregnancy might be difficult at this dose because unconscious coyotes and foxes sometimes exhibited muscle rigidity. Prolonged or invasive procedures would be inappropriate because coyotes and foxes occasionally exhibited movement and partial arousal showing that these animals were sedated rather than anesthetized. Medetomidine at 0.21 mg/kg immobilized most raccoons but, like coyotes and red foxes, sedation was incomplete, and muscle rigidity and movement occurred in some animals. Jalanka (1990) used medetomidine at 0.025–0.1 mg/kg in captive blue foxes (*Alopex lagopus*) and noted dose-dependent sedation but considered immobilization complete at 0.1 mg/kg. Likewise, Kreeger et al. (1996) reported that medetomidine at 0.05 mg/kg was effective for immobilizing captive gray wolves (*Canis lupus*). Several foxes and raccoons in our study required supplementary doses to achieve sedation, which we think reflected individual variation in the animals rather than methodological issues such as missed injections or underestimating the weight of animals. In fact, we generally overestimated the weight of these animals by 0.45 ± 0.3 kg and 0.15 ± 0.3 kg in foxes and raccoons, respectively. Biologists considering use of medetomidine on coyotes, red foxes, or raccoons in the field might evaluate higher doses than we used; however, before doing this it would be necessary to assess the safety of higher doses in clinical settings because medetomidine can have dose-dependent effects. Biologists should also more fully

examine other issues that arise in the field such as variation in ambient conditions or heightened capture stress. Ambient temperature appeared to have several effects in our study; for example, induction time was longer at warmer temperatures. However, given our applied objectives, we were unable to fully assess the implications of variation in ambient temperature on field immobilization in these species.

Nielsen (1999) noted body temperature, pulse rate, and ventilation rate in anesthetized raccoons as 37.5–38.7° C, 160–200 bpm, and 15–30 breaths/minute, respectively. Normal resting physiology in raccoons does not appear in the literature. Compared to Nielsen (1999), raccoons in our study exhibited bradycardia as would be expected with medetomidine. Alpha$_2$-adrenergic agonists can impair thermoregulation resulting in hypothermia or hyperthermia (Klein and Klide 1989). Higher than normal rectal temperature that we observed seems to contradict this, but transient increased temperature should be expected in animals that show physical exertion during capture and immobilization. Nielsen (1999) found normal resting body temperature, pulse rate, and ventilation rate in dogs to be 38.2–38.7° C, 90–100 bpm, and 15–30 breaths/minute, respectively. Kreeger et al. (1989) reported that resting body temperature and pulse rate in red foxes were about 40° C and 125 bpm, respectively. In gray wolves, resting body temperature and pulse rate were 39.7° C and 84 bpm, respectively (Kreeger et al. 1990*a*). As with raccoons, coyotes and red foxes in our study exhibited deviations from these values that would be expected given the known cardiopulmonary effects of medetomidine and the likelihood that animals experienced some stress during capture. For example, coyotes and foxes were bradycardic but had slightly elevated body temperature and ventilation rates. Ventilation rate was generally higher at higher ambient temperature, but as before, we were unable to fully assess the effects of ambient temperature. Oxygen consumption is a good expression of overall metabolic activity and, within normal tolerances, an increase in ventilation in capture-stressed animals at warmer temperatures would be expected (Schmidt-Nielsen 2001). Animals in our study became alert 4–9 minutes following atipamezole. This is consistent with studies on artic foxes and gray wolves that showed animals became alert 3–12 minutes following atipamezole (Kreeger et al. 1996, Aguirre et al. 2000). Jalanka (1990) noted that blue (arctic) foxes that received atipamezole at doses $\geq$0.25 mg/kg occasionally became nervous and developed muscle tremors. We generally observed smooth recovery with no discernable nervousness or muscle tremors.

Supplementary doses of medetomidine to red foxes and ketamine to raccoons effectively sedated these animals. Supplementary doses often are administered at 50% of the initial dose. We chose higher doses based on our need to ensure sedation and safe handling of these carnivores, our experience with the effectiveness of atipamezole for reversing medetomidine, and our observations that raccoons often required higher doses to achieve similar sedative effects. When determining supplementary doses, biologists should be aware of possible dose-dependent side effects of medetomidine, and that a mixture of medetomidine and ketamine initially may be appropriate depending on the objectives and conditions of the restraint event (i.e., Dzialak et al. 2002, see Kreeger and Arnemo 2007). Supplemented foxes had higher pulse rate than did single-dose foxes. These individuals appeared generally less responsive to the anesthetic effects of medetomidine including its bradycardic effects. Higher pulse rate in supplemented raccoons in our study could reflect ketamine pharmacology. This higher pulse rate, although well below the value of Nielsen (1999), is consistent with previous reports of dose-related tachycardia in carnivores restrained with ketamine (Ramsden et al. 1976, Fowler 1978, Haigh 1982).

Management Implications

Medetomidine at 0.12–0.14 mg/kg for coyotes and most red foxes, and at 0.21 mg/kg for most raccoons followed by atipamezole at 0.4 mg/kg, would be useful for brief, noninvasive field procedures such as radiocollar attachment, morphological assessment, collection of parasites and other samples, or ear-tagging. Persistent muscle rigidity, movement, and occasional partial arousal could make palpation for pregnancy or injury difficult. Medetomidine unaccompanied by other drugs is reversible, has broad availability, and has a wide safety margin. We observed no physiologic response that would be cause for concern. Considerations at the doses we evaluated included shallow sedation, partial arousal, and a general restriction to noninvasive procedures. Given the habitat conditions and restraint objectives in our study, medetomidine followed by atipamezole was an effective, practical alternative to other drugs or drug combinations. We recommend use of these drugs for similar procedures in field settings where full reversibility is advantageous, or when conditions otherwise require safe, efficient handling of animals.

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